

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

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WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

To:
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

Date of mailing
(day/month/year)

Applicant's or agent's file reference 5051.639.WO	FOR FURTHER ACTION See paragraph 2 below
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International application No. PCT/US04/18863	International filing date (day/month/year) 10 June 2004 (10.06.2004)	Priority date (day/month/year) 13 June 2003 (13.06.2003)
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International Patent Classification (IPC) or both national classification and IPC
IPC(7): H01L 21/00, 8238; 29/76, 94; 31/062, 113, 119 and US Cl.: 438/3, 216; 257/295

Applicant
NORTH CAROLINA STATE UNIVERSITY

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/ US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201	Date of completion of this opinion	Authorized officer Matthew Smith Telephone No. 571-272-1855
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WRITTEN OPINION OF THE
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Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

- ☒ the international application in the language in which it was filed
- ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

a. type of material

- ☐ a sequence listing
- ☐ table(s) related to the sequence listing

b. format of material

- ☐ on paper
- ☐ in electronic form

c. time of filing/furnishing

- ☐ contained in the international application as filed.
- ☐ filed together with the international application in electronic form.
- ☐ furnished subsequently to this Authority for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table(s) relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

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Box No. IV Lack of unity of invention

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees the applicant has, within the applicable time limit:
- ☒ paid additional fees
 - ☐ paid additional fees under protest and, where applicable, the protest fee
 - ☐ paid additional fees under protest but the applicable protest fee was not paid
 - ☐ not paid additional fees
2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is
- ☐ complied with
 - ☒ not complied with for the following reasons:
See the lack of unity section of the International Search Report (Form PCT/ISA/210)

4. Consequently, this opinion has been established in respect of the following parts of the international application:

- ☒ all parts.
- ☐ the parts relating to claims Nos. _____

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Box No. V Reasoned statement under Rule 43 bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)

Claims 1-9,14,18,21-23,27,28,30 and 32 YES

Claims 10-13, 15-17, 19-20, 24-26, 29, 31 NO

Inventive step (IS)

Claims 1-9,14,18,21-23,27,28,30 and 32 YES

Claims 10-13, 15-17, 19-20, 24-26, 29, 31 NO

Industrial applicability (IA)

Claims 1-32 YES

Claims NONE NO

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Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

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Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the questions whether the claims are fully supported by the description, are made:

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

V. 2. Citations and Explanations:

Claim 1 an inventive step under PCT Article 33(3) as being obvious over Nakamura et al., US Patent No. 6,097,058.

Nakamura meets:

limitations from claim 1, a semiconductor device comprising:

in fig. 12A, a first oxide layer 42 on the semiconductor substrate, Si, the first oxide layer 42 comprising an element from the semiconductor substrate, col. 9, line 24-34;

a second oxide layer 44 on the first oxide layer opposite the semiconductor substrate, the second oxide layer comprising a stoichiometric, single-phase complex oxide represented by the formula:

$AhBjOk$, or equivalently $(AmOn)a(BqOr)b$

in which the elemental oxide components, $(AmOn)$ and $(BqOr)$ are combined so that $h = j$ or, equivalently, $ma = bq$, and a, b, h, j, k, m, n, q and r are non-zero integers; and

wherein:

A is an element of the lanthanide rare earth elements of the periodic table or the trivalent elements from cerium to lutetium; and

B is an element of the transition metal elements of groups IIIB, IVB or VB of the periodic table: Gd_2Ti_2O , col. 9, lines 4-14;

limitations from claim 3, a device according to Claim 1 wherein the second oxide layer has a band gap of greater than about 5.5 eV, Gd_2Ti_2O , col. 9, lines 4-14;

limitations from claim 4, a device according to Claim 1 wherein the second oxide layer has a conduction band offset energy of greater than 1.5 eV, Gd_2Ti_2O , col. 9, lines 4-14;

limitations from claim 6, a device according to Claim 1 wherein B is an element with 3d, 4d or 5d electrons available for bonding to oxygen, and wherein A is an element in which one 5d electron is available for bonding, Gd_2Ti_2O , col. 9, lines 4-14;

limitations from claim 7, a device according to Claim 1, wherein B is scandium, titanium, tantalum or niobium: Gd_2Ti_2O , col. 9, lines 4-14;

limitations from claim 8, a device according to Claim 1, wherein B is scandium, titanium, tantalum, or niobium (Nb) and wherein A is trivalent gadolinium, praseodymium or lutetium, Gd_2Ti_2O , col. 9, lines 4-14;

limitations from claim 14, a device according to Claim 1, wherein the substrate comprises a material selected from the group consisting of silicon (Si), germanium (Ge), silicon carbide (SiC), gallium nitride (GaN), gallium arsenide (GaAs), and combinations thereof: Si, col. 3, lines 57-63;

limitations from claim 18, a device according to Claim 1, wherein the device comprises a field effect transistor, col. 9, lines 24-33;

limitations from claim 21, a method of forming a semiconductor device comprising: in fig. 12A

providing a semiconductor substrate Si;

forming a first oxide layer 42 on the semiconductor substrate,

forming a second oxide layer 44 on the first oxide layer opposite the

semiconductor substrate, the second oxide layer comprising a stoichiometric, single-phase, complex oxide represented by the formula:

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

 $AhBjOk$, or equivalently $(AmOn)a(BgOr)b$

in which the elemental oxide components, $(AmOn)$ and $(BgOr)$ are combined so that $h = j$ or, equivalently, $ma = bq$, and a, b, h, j, k, m, n, q and r are non-zero integers; and wherein:

A is an element of the lanthanide rare earth elements of the periodic table or the trivalent elements from cerium to lutetium; and

B is an element of the transition metal elements of groups IIIB, IVB or VB of the periodic table: Gd_2Ti_2O , col. 9, lines 4-14;

limitations from claim 22, a method according to Claim 21, further comprising:

exposing the substrate to one or more gaseous sources comprising elements A,

B, and oxygen such that one or more gaseous sources react to form the second oxide layer, either in growing or depositing of an oxide, oxygen gas is used or evaporates and will react with the substrate;

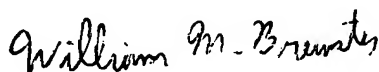
limitations from claim 23, a method according to Claim 22, wherein the one or more gaseous sources comprise an amount of oxygen sufficient to substantially oxidize elements A and B: SiO_2 is formed, col. 3, line 66 - col. 4, line 3;

limitations from claim 27, a method according to Claim 21, wherein B is an element with 3d, 4d or 5d electrons available for bonding to oxygen, and wherein A is an element in which one 5d electron is available for bonding as in trivalent ions: Gd_2Ti_2O , col. 9, lines 4-14;

limitations from claim 28, a method according to Claim 21, wherein B is either scandium, titanium, tantalum or niobium: Gd_2Ti_2O , col. 9, lines 4-14;

limitations from claim 30, a method according to Claim 21, wherein the device comprises a field effect transistor, col. 3, lines 58-63;

Claims 11-13, 15-17, 19, 20, 24-26, 29, 31, 32 the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest the claimed features.

WILLIAM M. BREWSTER
PRIMARY EXAMINER